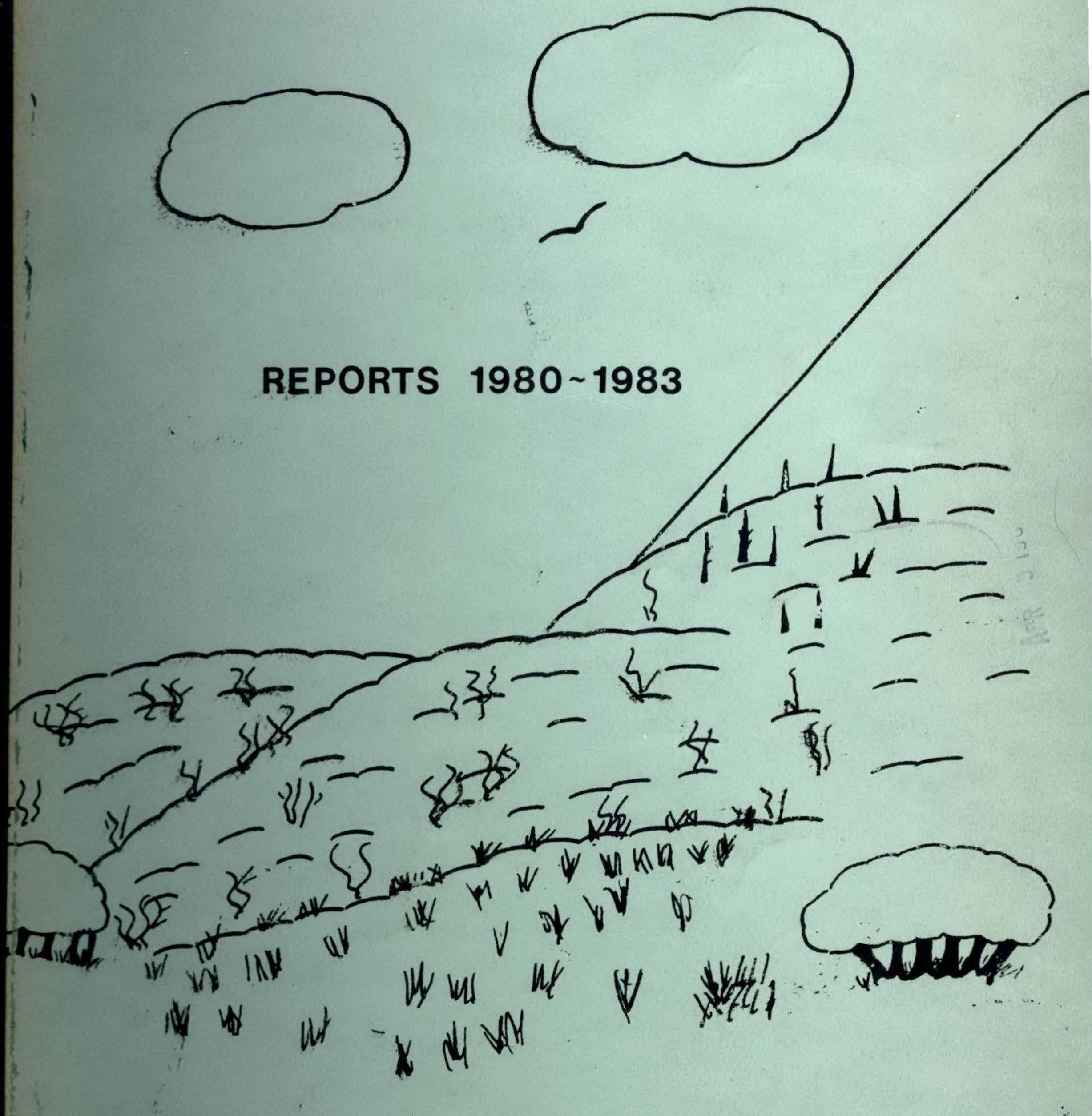
HE SOBOBA PROJECT

CHAPARRAL MANAGEMENT



REPORTS 1980~1983

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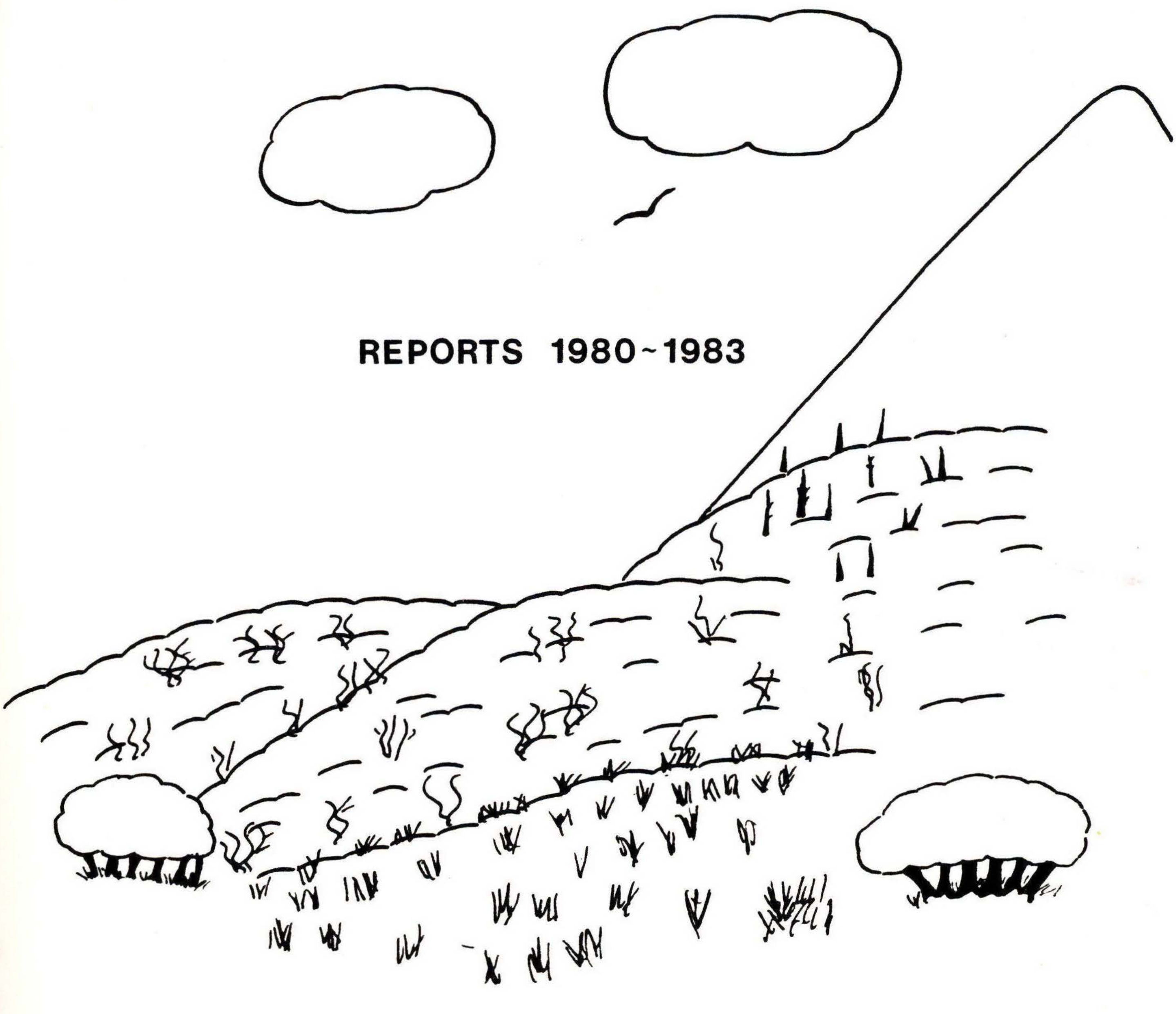

REPORTS 1980~1983

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APPROACHES TO CHAPARRAL MANAGEMENT FOR WILDLIFE

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ABSTRACT

The Soboba Project on the San Bernardino National Forest is an effort to combine several strategies of chaparral management on 12,000 acres of typical Southern California brushland. In chaparral, as in any ecosystem, biomass can be made to concentrate in higher trophic levels. Fire is an obvious agent, but different fire regimes applied to different cover types can produce a wide range of results. Burn planning is discussed, including size, season, rotation and alternatives.

Other approaches deal with more subtle agents: structural diversity, the balance of protein and carbohydrates available to herbivores, and topographic factors which allow organic soil production and determine the distribution of water. Oak silviculture is considered as a technique for supplying the basic energy needed to exploit fully the temporary post-fire protein surges. Oaks and other valuable shrubs can be cultivated in conjunction with passive water impoundments which in the short run provide increased free water and later silt in to become plateaus with stable aquifers and more fertile soils.

A balance of all these elements -- carefully applied prescribed burning, water development and silviculture -- is described as a program to optimize wildlife numbers and diversity within the limits of natural processes.

CAL-NEVA WILDLIFE TRANSACTIONS 1980

APPROACHES TO CHAPARRAL MANAGEMENT FOR WILDLIFE

Introduction

In chaparral, as in any ecosystem, biomass can be made to concentrate in higher trophic levels. The premise that solar energy can be maneuvered from the production and maintenance of woody plant tissue into forms more accessible to herbivores is central to most vegetation management programs for wildlife. I re-state it because the apparent simplicity and uniformity of chaparral has led to some rather simplistic views of its manipulation. We should remind ourselves that chaparral is to be treated as an ecosystem, including both biotic and abiotic elements, and our approaches must match, to the fullest extent possible, its strengths and weaknesses as a natural mechanism for generating animal biomass.

The Soboba Project is a chaparral demonstration area on the San Jacinto District of the San Bernardino National Forest. After a year of planning, the designers of the project have hopefully arrived at this ecosystem approach. I want to outline the development of the Plan and our thinking on chaparral wildlife management. We're nowhere near the end of the process, but we might be able to shorten the brainstorming time for others involved in brushland improvement, and to suggest some avenues for research that will bear immediate fruit in this increasingly important field.

A "Demonstration Area" label is a direction to operate a little like a farmer raising a cow for meat and milk at the same

time. Our mandate is simultaneously to investigate and implement the best management practice where little or no groundwork has been laid. For either a scientist or a manager it is a difficult balance to strike; I trust this will help rationalize away the occassional ambivalence of our approach.

We all know by now that the Forest Service policy of vigorous brushland fire suppression has left us with hundreds of thousands of acres of decadent vegetation, increased wildfire danger and decreased quality of wildlife habitat. It's a relatively new idea that has rapidly acquired the status of a cliche, and I don't think I need do more than refer to it.

On our district, we had a classic case: 12,000 "useless" acres south of the Banning-Idyllwild Highway. The Forest Service took charge of it in 1905, and for most of the century treated it in its usual role of over-protective custodian. The area had been little more than a grudging watershed for the San Jacinto River, from its last recorded fire in the 1890's until the inevitable happened in 1974. A fire started on the adjacent Soboba Indian Reservation and burned catastrophically, well into the timbered slopes above the chaparral.

California Fish and Game saw in this an opportunity to claim an area where wildlife could for once be a priority item in the multiple-use scramble. After a couple of years of hounding, they got their way, and a joint planning team was formed, consisting of Fish and Game and Forest Service personnel.

The Role of Fire

We came immediately upon the words inscribed in the mind of every neophyte chaparral manipulator: Burn it. This is, of course, not a new idea. Post-fire improvements in animal numbers and diversity have been documented by authors in California since the 1950's (Biswell 1957; Biswell and Gilman 1961; Gibbens and Schultz 1963; Dasmann et al. 1967).

It is a technique of unquestioned usefulness, but was it all that we needed? Questions about the overall efficiency of burning were raised even before the ranks of its advocates began to swell (Zivnuska 1967). In our own case, preliminary monitoring found highest numbers and diversity of wildlife species in several areas that could not be managed by fire -- certain types of oak associations and riparian areas. And as we entered the literature on burning, we could produce only two studies that quantitatively addressed the question of nutritional plane of animals on burned vs. unburned chaparral. The earliest, the classic study of Taber and Dasmann (1957) did indeed show higher populations and better doe/fawn ratios on burned chaparral. The study also showed that a mixture of shrub and herbaceous understory could do as well, or better, than post-fire brushland. A more recent study (Longhurst and Connolly 1970), using somewhat more precise indices of nutritional condition, could not duplicate these results. They found no significant difference between burned and unburned chaparral. They did, however, agree with the earlier work in one intriguing respect. They established a consistently higher nutritional plane for

mule deer occupying a nearby range whose cover was oaks over herbaceous vegetation.

In my view, the ambiguity of the results of the two studies reflected the relative paucity of chaparral at the best of times, and the very short rejuvenation period following fire (Lillywhite 1977). One hypothesis could be that deer must be at the proper population density, and have access to a certain mix of other cover types, before they can fully exploit the rather sparse benefits of prescribed burning. Another way of stating this is that rejuvenated browse might not be the principle limiting factor for deer or other chaparral wildlife, and thus burning, while it might be the centerpiece of our management effort over the long run, did not address our problems, or the potential of chaparral, completely enough.

Preliminary enquiries at the Riverside Forest Fire Lab (Green, pers. comm.) brought up more questions about burning. Different intensities or rotation periods on different cover types can produce widely different results. For instance, burning a chamise-annual grass association on a rapid rotation cycle (say 5 years) can convert an area to grass; at a ten year rotation it would be managed as rejuvenated browse.

Other associations and species offer an equal range of choices, and more unknowns. Mountain mahogany (*Cercocarpus betuloides*), a prime deer browse species on our range, is a tricky one to burn, and some authorities believe it responds better to crushing (Biswell and Gilman 1961; Gibbens and Schultz 1963). Fall burning is better than spring burning for non-

sprouters. Split-germination ceanothus can require a complex alternating fire and herbicide treatment for best results (Ashcraft pers. comm.). One of the plants we're most interested in is the bush poppy (Dendromecon rigida), and virtually nothing has been published on its ecology relative to fire.

So where were we? We knew that fire is a cheap and generally good tool for improving habitat. Longhurst and Connolly's (1970) study had cast some doubts on its cure-all properties and suggested, along with the earlier work of Dasmann and Taber (1957) that the oak-herbaceous mix is an extremely valuable microhabitat in chaparral whose management might offer an even greater potential.

Let's address the use of fire first. On the Soboba Project, we have the option of a few years grace before the fuels management problem ascends to priority number one. With the luxury of time, we can lay out a plan which will optimize the benefits of prescribed burning. The process is summarized in Figure 1.

Phase One: Classification of Vegetation

We have begun this using color infrared aerial photography, with a definition down to about five acre plots. With this much detail, there is a great deal of classification to be done, and the key to getting it finished in a reasonable amount of time is a simple classification system geared to potential manipulations. We record age, dominant species in the canopy and understory, and percent slope, a general index to the practicality of field operations on the site.

Phase Two: Site Preparation

Here we borrow heavily from the Grindstone model. I should have acknowledged earlier that the Grindstone Project on the Mendocino National Forest is, in spirit, the grandfather of all programs of this type and its lessons are clear and well-advised. The Grindstone "recipe" is to do relatively long and narrow type conversions on secondary ridgetops. In the short run, this program provides green herbaceous feed and structural diversity. In the long run, they serve as control lines for prescribed burning on the adjacent slopes.

Phase Three: Habitat Criteria

The Wildlife Habitat Relationships Program is the most succinct source for profiles of cover types for target wildlife species. The program is being developed by various state and federal agencies, with the goal of allowing the land manager to predict the effects on wildlife of management activities. Using the guides for deer, for example, we can characterize optimum summer habitat (Holl, pers. comm.) as:

55% Palatable grasses and forbs, .3-.6 meters high.

30% Dense but penetrable grass or brush, .6-.9 meters high.

15% Interspersed trees greater than 3 meters tall

We can do the same thing for another target species or, by making some compromises, for overall species diversity in an area.

The procedure for putting all three phases together will involve firstly, using the classification system to determine what criteria are already fulfilled on a site. Then we know exactly what is not needed. Secondly, we develop a concise list of ob-

jectives which, when matched with the existing cover and the state-of-the-art on burning, generates a prescription as to what should be burned, and how often.

Burning executed on this basis is more complex than most prescribed burn plans based exclusively on fuels modification requisites, and the interface between the two approaches may cause some problems at first. But everything we've learned thus far indicates that there will be an eventual pendulum swing away from prescribed burning for wildlife unless we do it right from the first. And prescribed burning is new enough, at least on federal lands in Southern California, that if we learn how to do it best we can pass our knowledge on to fuels managers, to the benefit of both resource concerns.

Oak Silviculture and Topographic Management

Turning to the question of managing oak michrohabitats, let's limit ourselves to mule deer for the moment, and take a nutritionists point of view. Apart from vitamins and minerals, which are legitimate concerns but perhaps too elusive to involve use, animals need protein and carbohydrates. Portein is required for growth, especially fetal and neonatal growth, and carbohydrates for the basic maintenance fuel. Mature chamise/manzanita chaparral has short rations for both.

Fire provides a temporary surge in protein and makes certain types of carbohydrates more available (Bell 1973) but often not in the right place at the right time. A pregnant doe entering the winter needs an ample supply of carbohydrates to carry herself through to parturition. She needs a supply of protein

rich foods at key points during gestation and lactation. She needs these items but finds that instinct limits her to an increasingly small territory, eventually the eight acres of the fawning area.

A twenty acre prescribed burn, let alone some of the burns now being planned at the scale of several hundred acres, may not be accessible because of its placement. It may be only marginally adequate in the protein it provides, in the quantity or quality of cover for the fawn, in its water supply.

This may be the reason for the importance of the oak-herbaceous association, at least relative to deer, noted in the studies cited. "Green feed", stable grass/forb/legume cover, is a protein source superior to burned chaparral, and the hospitable oak is one of the best carbohydrate suppliers in nature.

Can we manage for it? I think we can, but not with fire; we can extend or reproduce these areas by managing the landforms themselves; by extending our manipulations of the chaparral ecosystem into its abiotic sphere: the topography.

The idea is not mine. It springs from a concept developed in Australia and called "Keyline". Its intent is to harness the natural processes of hydrology and soil movement in areas with highly erodable soils and highly seasonal rainfall.

To sketch out our version, we should first look at a normal cover system we'd expect to find in chaparral (Figure 2). Below a primary ridge we have a succession of lateral ridges with a chamise/manzanita combination and perhaps some shrub-form live oaks. The soil is predominantly decomposed granite, the slopes

in the neighborhood of 30%. One of the reasons for chaparral in the first place (de Bano 1974) is that fine soils are continually eroding from the steep ridge system and depositing on the flats below as the velocity of streamflow is suddenly reduced. Here we find the deeper, slightly wetter soils which can support more of an oak-parkland type. On the Soboba Project site, these would be coast live oaks (Quercus agrifolia) over herbaceous vegetation or some of the more demanding and hydrophytic shrubs such as Ceanothus integerrimus or Rhamnus californica. Depending on the amount of water in the system, these areas can be classified as riparian, and the association can extend back up the drainage as far as the primary ridge.

The central teaching of the Keyline concept is that this soil-vegetation assembly can be duplicated at any elevation we choose, to create pockets of oak-parkland in otherwise homegeneous chaparral. We accomplish this by first impounding the drainage with a dam (Figure 3). Providing year-around water on such a site is the first of many benefits. In the long run, what we create is a plateau, smaller but topographically identical to the flats below. If we cultivate or manage oak trees surrounding the impoundment (Figure 4), they will eventually, along with the more hydrophytic berry producing plants, become the stable cover on the site, persisting indefinitely after the impoundment has silted in because here, on the miniature flat, the same processes of soil deposition and aquifer formation are taking place.

Putting it all together (Figure 5) gives us one of those models that look good on paper but may never find complete appli-

cation in the field. Beyond the obvious problems of ridge systems that look more like something that fell off the back of a truck, the science of planting or managing oak trees is in its infancy. We do have some help. The Liebre Mountain Oak Project on the Angeles National Forest gave us enough guidance to establish an experimental nursery for black (_Q. Kelloggii_) and canyon live oaks (_Q. chrysolepis_) to plant on this type of site.

The overall scheme, then, is first to impound the drainage and to type convert the adjacent ridge or ridges. The impoundment leads to the creation of a tree-form oak grove and a stable water supply. The ridgetop type conversion gives us an immediate supply of herbaceous feed, hopefully within the home range of a pregnant doe, and sets the whole complex up for a safe and well-planned burning program.

The largest investment, and the phase requiring the most artifice, is the inital one. Thereafter, all the elements -- burning, oak silviculture and topographic management -- fall within the realm of processes that can and do occur naturally. The productive capability of chaparral is maximized based on a groundwork that can be substained indefinitely without any drain on non-renewable resources.

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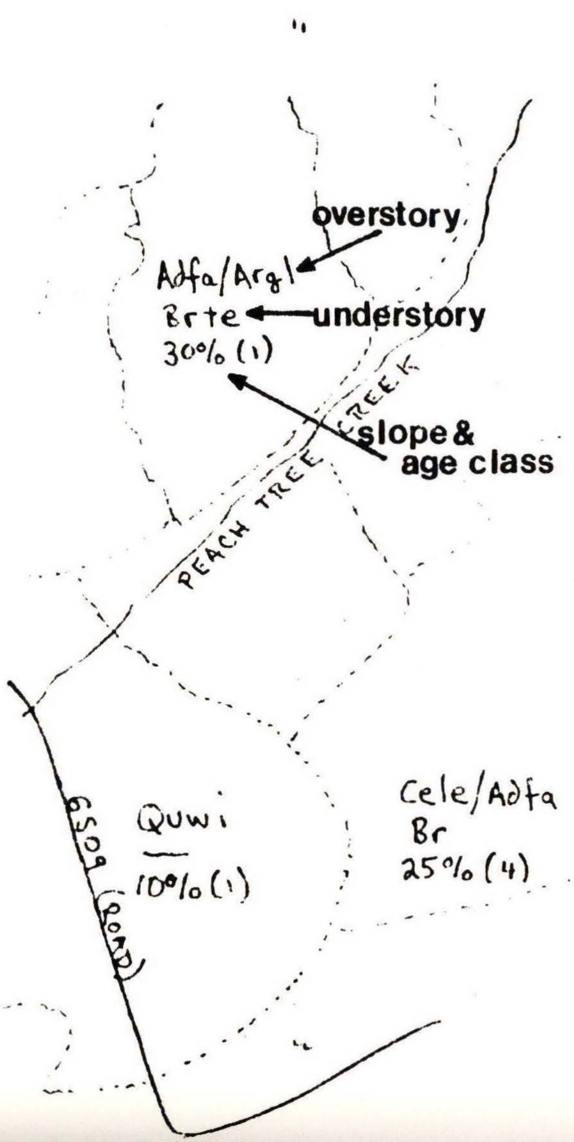
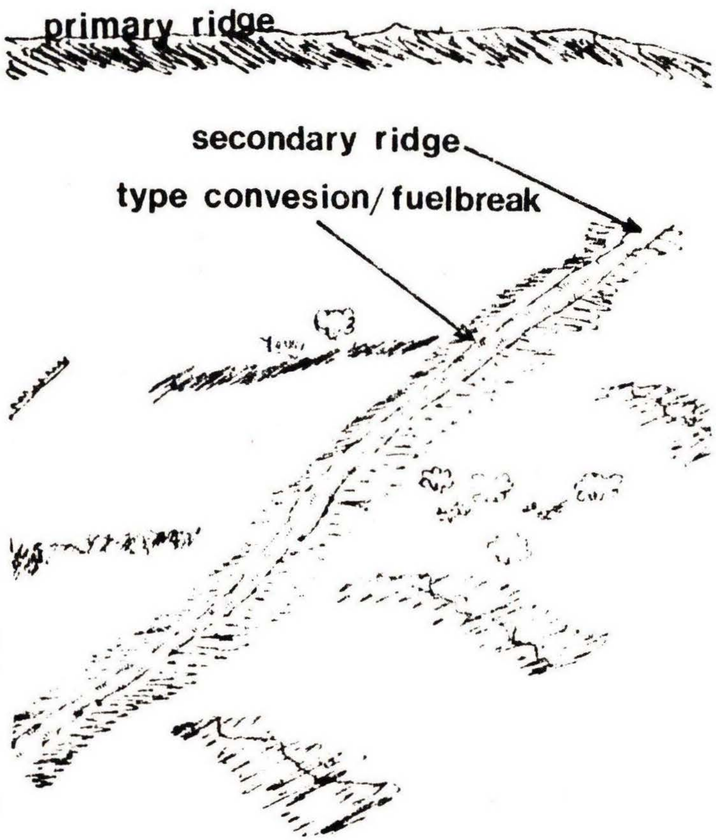
FIGURE 1. Prescribed burn planning.

PRESCRIBED BURN PLANNING

I. classification



II. site preparation



III. habitat criteria

deer (summer)

55% palatatable grass/forb

30% penetrable brush

15% trees >10' tall

FIGURE 2. Typical ridge formation and cover in chaparral.

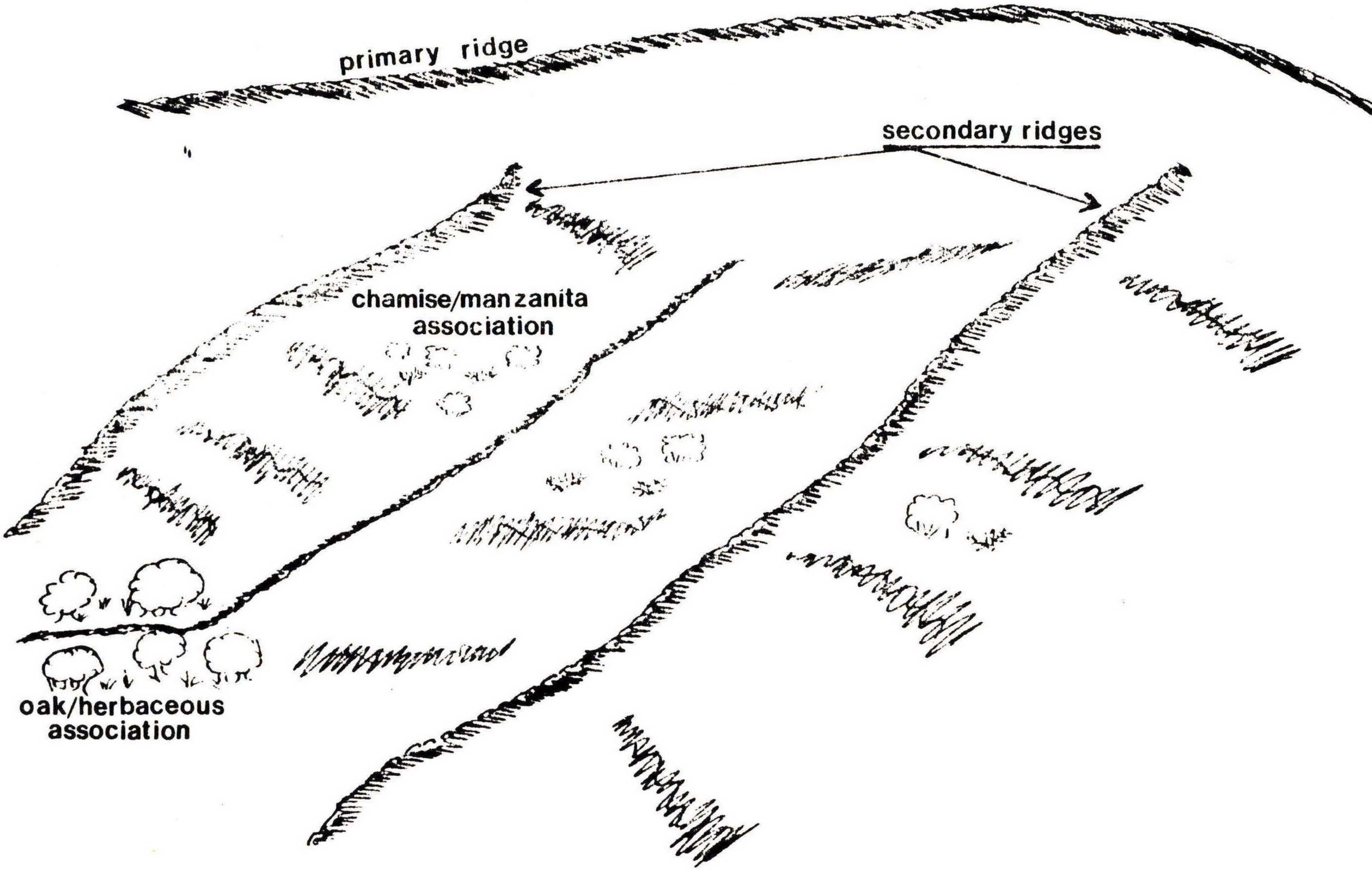

primary ridge
secondary ridges
chamise/manzanita association
oak/herbaceous association

FIGURE 3. Impoundmnent of drainage.

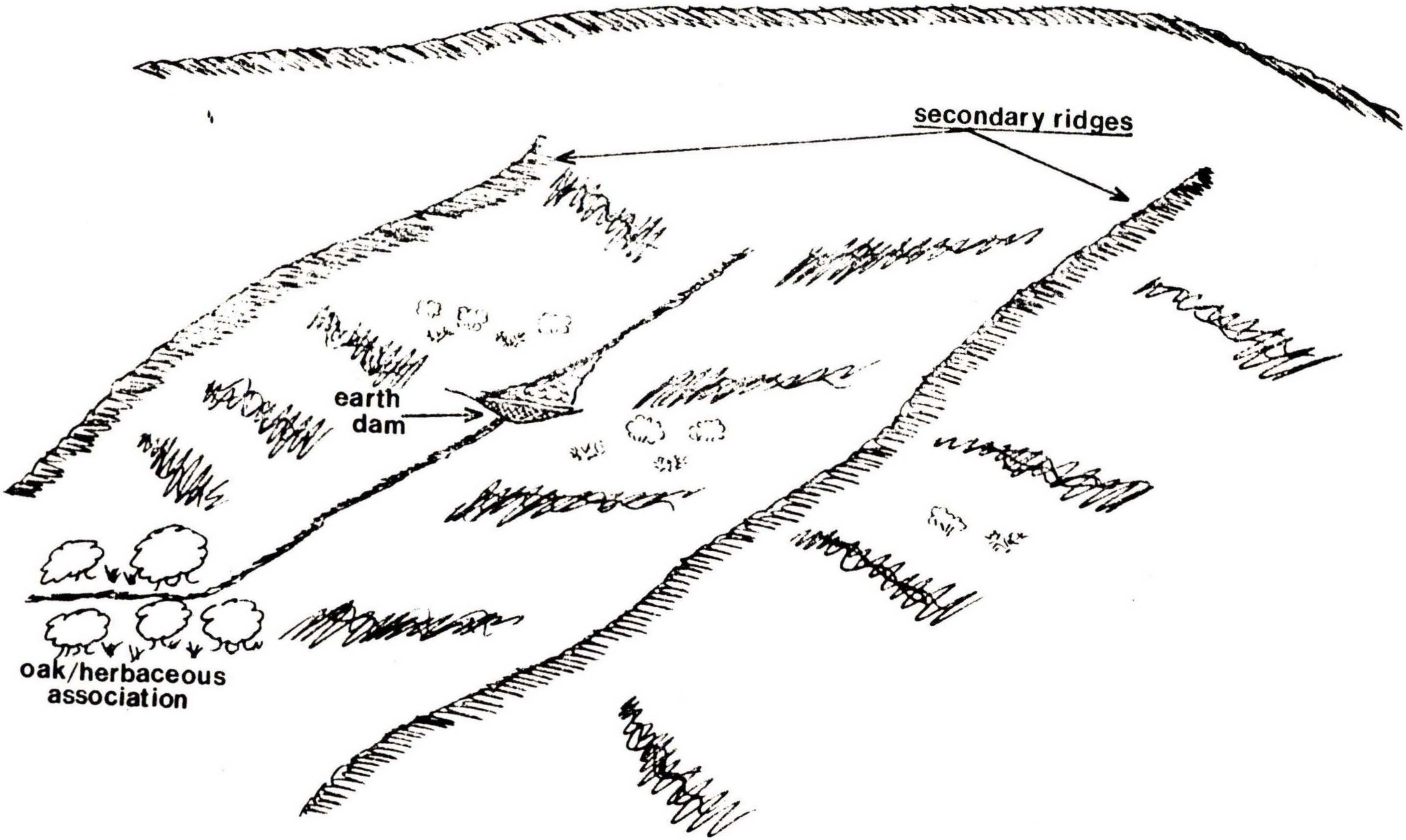

secondary ridges
earth
dam
oak/herbaceous
association

FIGURE 4. Oak silviculture on drainage.

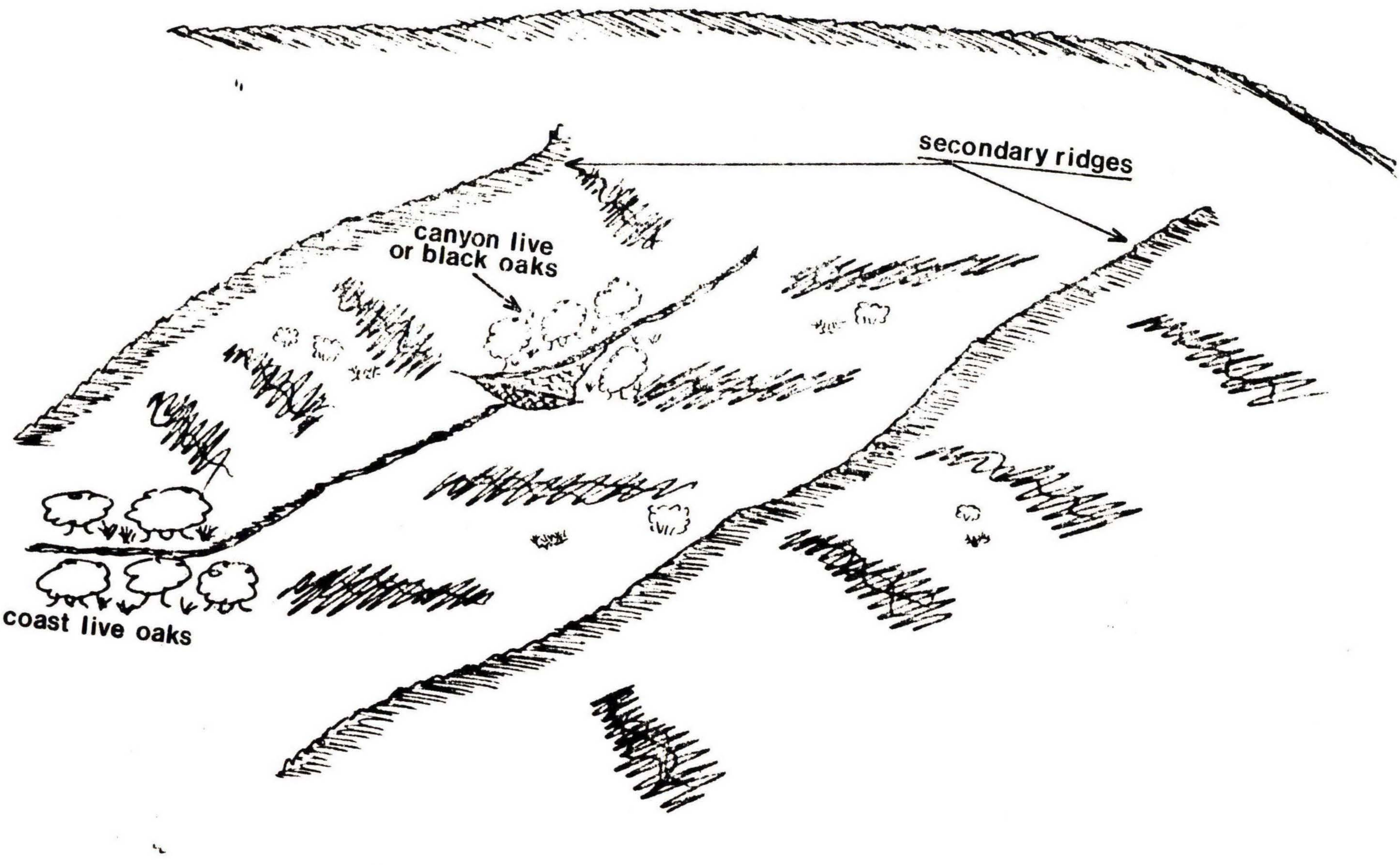
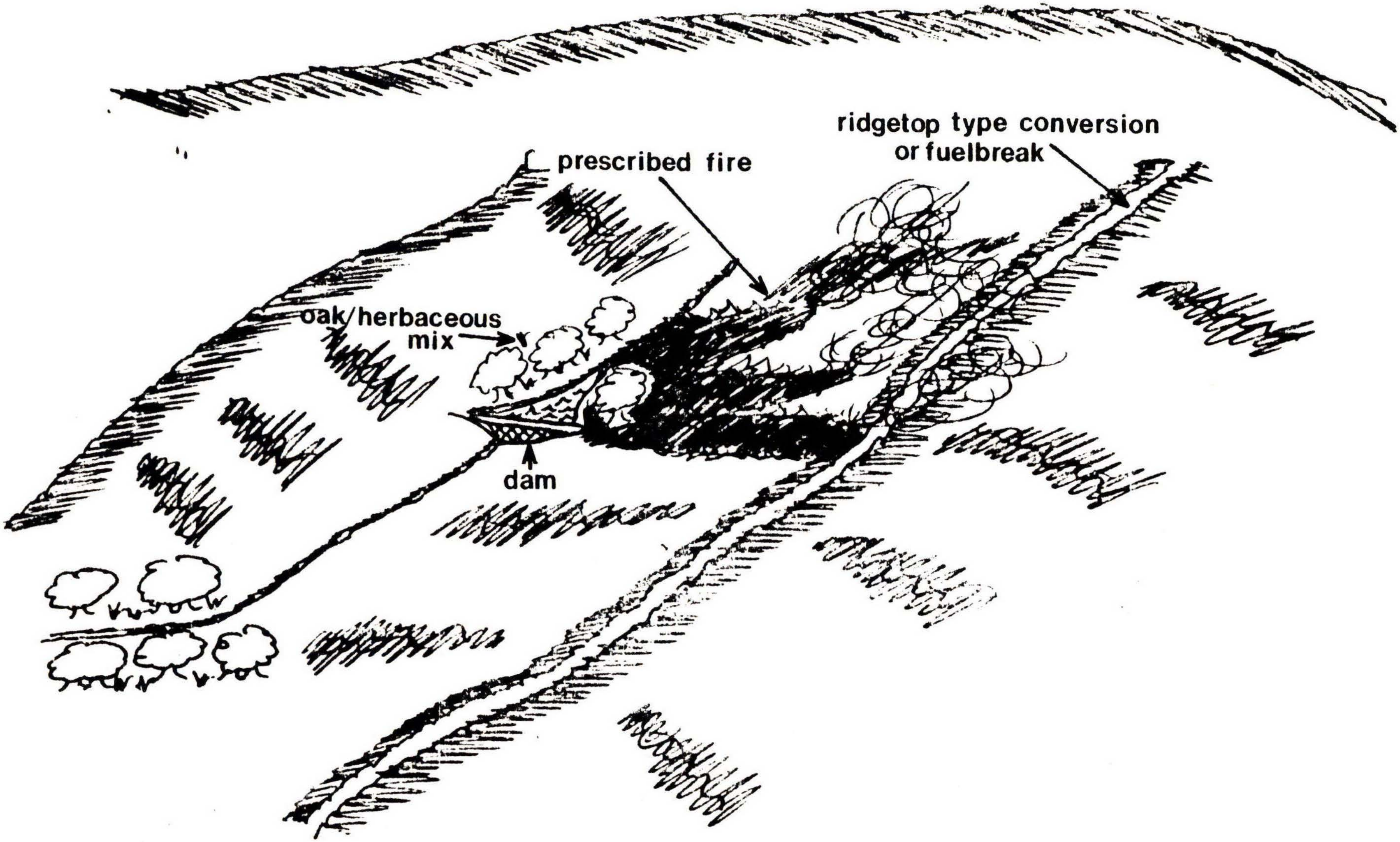

secondary ridges
canyon live
or black oaks
coast live oaks

FIGURE 5. Complete management model.


ridgetop type conversion
or fuelbreak
prescribed fire
oak/herbaceous
mix
dam

THE SOBOBA PROJECT: PRELIMINARY EVALUATION OF HABITAT IMPROVEMENT TECHNIQUES

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ABSTRACT.

Preliminary data points toward prescribed burning as the most effective method of improving chaparral. Placement of a burn near water can noticeably increase the benefits of that burn. During the first year after discing and brush raking, deer use declined, along with a significant drop in small mammal productivity on the disced site. Deer response to hand cutting of brush and water impoundment were both positive. This suggests that burning adjacent to natural or artificial water sources, with handcut control lines where possible, represents the best first step in a chaparral management program.

INTRODUCTION

Chaparral manipulation methods utilize both mechanical equipment and prescribed fire to reduce hazardous fuels accumulation and improve wildlife habitat. Both of these approaches have been used for several decades in southern California. It is known that mature (decadent) brushfields are low in wildlife productivity and diversity. Still, the contention that any technique reversing succession in chaparral benefits animals is unsubstantiated. Claims that brush-to-grass type conversion improve wildlife habitat is conjectural at best (USFS 1972). In Texas, deer preferred brush range to root plowed and seeded ranges (Davis and Winkler 1968). Lillywhite (1977) noted a decline in diversity and abundance of lizards and small mammals after brushland to grassland conversion in San Diego County. Although some studies indicate prescribed fire can be used successfully for habitat enhancement (Biswell et al., 1952; Taber 1953; Taber and Dasmann 1957; Cowles 1958; Biswell 1961; Biswell and Gilman 1961; Gibbens and Schultz 1963; Lawrence 1966; Longhurst 1978; Wirtz 1979), other studies demonstrate inconclusive results (Dasmann et al., 1967; Longhurst and Connolly 1970).

The Soboba Project is a chaparral management project jointly planned by the U.S. Forest Service and the California Department of Fish and Game. The project area occupies a 12,000 acre watershed in the San Jacinto Mountains. This project is studying a wide range of improvement techniques, including prescribed burning, water development, oak silviculture and several types of mechanical treatment. In order to obtain an indication of which techniques, or which combination of techniques, achieve the best results, response data has been documented on at least one site representing each type of treatment. This report describes the preliminary findings for deer and small mammals.

Deer and small mammal populations (Figure 1) showed a rapid increase for 5 years following the 1974 fire. This pattern reflects the relatively short-lived increases in nutritive quality of the forage (Biswell 1961; Bell 1974). Using these data as a baseline, the Soboba Project offers a unique opportunity to develop a brushland treatment "mix" that, can be tailored to local conditions in order to give the best results for each dollar invested.

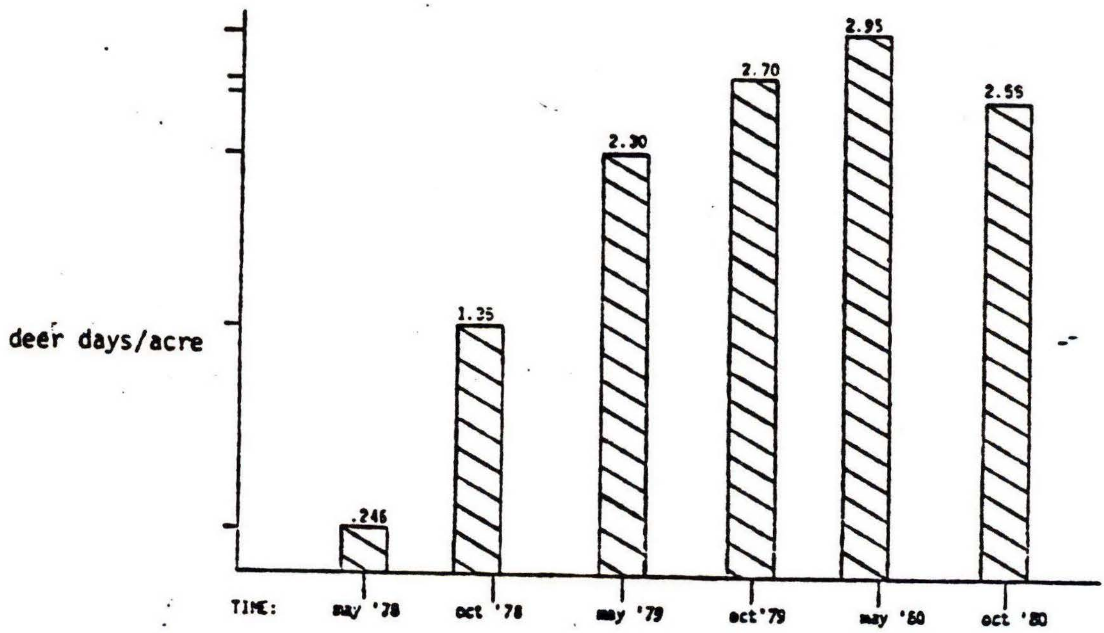

Figure 1. Deer Days/Acre of the Soboba deer herd since 1978.

Manipulations were carried out between December 1979 and June 1980 on sites that had not burned in the 1974 fire. Prescribed burn sites were similar in slope, exposure, and dominant species (Table 1). Both prescribed burns were conducted in the spring using the helitorch ignition method, and resulted in the removal of 40%-50% of the vegetation on each site. The chief difference between the two sites was the presence of a small spring at one end of the Oak Flats site. The Indian Mountain site was intentionally laid out so that no point was nearer than 160m (480 ft.) to a water source through heavy brush.

Table 1. Vegetation structure on prescribed burn sites in the Soboba study area 1979 - 1980.

	Importance values (a)	
	Adenostoma fasiculatur	Arctostaphylos (spp.)
Oak Flats	118	141
Indian Mountain	104	98

a. Importance value is the sum of the values for relative density, relative frequency and relative cover obtained on random transects run through the burned area.

A Caterpillar D-7 crawler tractor was used for both discing and brush raking operations, (for equipment descriptions see Larson 1980). The discing was done with a Towner Disc which uproots, chops and reburies vegetation. The brush rake uproots a significant portion of whole shrubs and piles them. Disced sites were seeded with a combination of annual and perennial grasses and legumes. Brush raked sites were allowed to revegetate naturally. Hand-cleared sites were part of a timber stand improvement operation. Shrub species were chopped back close to ground level but not uprooted.

We wish to express our thanks to the Riverside County Fish and Game Commission which financed much of the project work, and to our tireless and thorough field crew, Connie Anderson and Ron Tiller, of the Young Adult Conservation Corps.

MATERIALS AND METHODS

Deer use data in the project area was collected using fixed .001 ha (.025 ac) pellet group count plots. These plots were chosen in pairs 10m (33 ft) apart along staked lines, stratified according to vegetative types. Sampling on treated sites was conducted before and after treatment (fire, discing, etc.) using strip transects 10m (33 ft) wide which were located along the centerline of treated areas. Fixed plot pellet group counts have been conducted semi-annually (May and October) since 1978. Strip transects have been conducted twice since 1978, with pellet groups appearing older than three years excluded.

Small mammals were trapped in 7.6 x 7.6 x 23cm (3 x 3 x 9 in) Sherman live traps. The traps were spaced 15m (49 ft) apart along lines located in similar habitats in both the treated and control areas. Trapping was conducted during November the year before treatment and the year after. Each line transect was trapped for an average of 60 trap nights. The control areas were selected by line intercept sampling to determine vegetative structure and species similarity to the treated areas, (Smith 1974).

The sites which were brush-raked and hand-cleared were not planned for formal study and occurred as a result of other activities in the Soboba Project area. Therefore, only fixed plot deer use data are available for these areas. All deer use data are expressed in terms of deer-days/acre, adjusted to eliminate the influences of population increases over the project area as a whole.

RESULTS

DEER

Prescribed burning was the most effective treatment for increasing deer usage during the first year following treatment. The Oak Flats burn demonstrated the greatest improvement, transforming an area with very low deer activity into one with almost twice the average deer activity on the watershed (from 0 to 4.67 dd/ac). The Indian Mountain burn was designed to limit access to water. This burn resulted in a noticeable increase in deer usage, although not as large as the Oak Flats burn (Table 2).

Hand cutting brush produced a six-fold increase in deer use. A permanent summer water supply produced a 70% increase over the previous year. Areas in which discing and brush raking were utilized decreased deer use by 66% and 35% respectively in the first year following treatment. This "type conversion" approach produces bare soil, and relies on either natural or planted regeneration, both of which take time to restore forage.

SMALL MAMMALS

There was a significant difference in trapping success between the control line and the proposed burn site. The control line trapping success was lower than that of the proposed burn site. Following the burn, the trapping success decreased from .45 animals/trap night to .32 in the burned area (Table 3) making it not significantly different from the control. This decline in small mammals would be expected due to the removal of cover and food sources. However, this decline is still within the range of known small mammal use of unburned chaparral. Mortality due to the fire itself was low. Several woodrats (Neotona sp.) were seen escaping the fire shortly after ignition, and two Peromyscus californicus marked in 1979 were recaptured a year later.

Table 2. Response of deer to different chaparral manipulation techniques on the Soboba study area 1979 - 1980

Treatment	Site	Before Treatment (deer days/acre)	After Treatment (a) (deer days/acre)
Prescribed Burn (water available)	Oak Flats	0	4.67
Prescribed Burn (water unavailable)	Indian Mountain	0	1.84
Water Impoundment	Buck Springs	2.3	3.9
Type Conversion (using Towner Disc)	Buck Springs	.83	.28
Hand Cutting of Brush	Bay Tree Springs	.05	.30
Brush Raking	Mellor Ranch	3.1	.46

a. Adjusted for overall herd population changes during sampling period.

Table 3. Response of small mammals to two caparral manipulation techniques on the Soboba Study Area 1979 - 1980

Treatment	Site	Before treatment (captures/trap night)	After treatment (captures/trap night)
Oak Flats Prescribed Burn	Treated	.45 (a)	.32
	Control	.18	.43
Buck Springs Type Conversion (Towner Disc.)	Treated	.6 (a)	.09 (a)
	Control	.35	.60

a. Difference between Treated and Control significant ($p < .05$).

The area proposed for discing was found to have a significantly higher number of small mammals than the control area to the discing. Following discing the small mammal population dropped significantly in the treated area, from .6 animals/trap night to .09, well below that of the control site. Five species were trapped prior to treatment and only 2 species in the year following treatment.

DISCUSSION

Prescribed burning has long been advocated (Taber and Dasmann 1957; Anonymous 1961) as the mainstay of chaparral management for wildlife, and the preliminary results from the Soboba area clearly support this view. Deer use increased immediately and markedly after fire, while mechanical work produced the opposite effect. Small mammal abundance decreased after both types of manipulation, but the post-fire decrease was far less.

In dollar terms, even the most costly burns are no more expensive than mechanical work. Furthermore, costs of prescribed burning can be expected to decrease as experience grows and because larger acreages can be burned with less manpower.

There are, however, additional considerations. Some burns are more effective than others. The relative dryness of the Indian Mountain site appears to have limited deer use and the overall "usefulness" of the burn. This, together with the positive response to our water impoundment, identified the importance for careful placement of burns with respect to other potentially limiting factors (Roberts 1980).

The benefits of burning are short-lived, as indicated by the population trend since the 1974 wildfire. At the same time, most of the Soboba area is not yet ready for a reburn. In a post-fire rehabilitation effort such as this one, rotational burning is difficult to begin because the age class is uniformly too young. Once vegetation is established at a type conversion site, it can produce stable, high protein forage sources similar to those produced by prescribed burning. Type conversion is thus a valid method for maintaining high quality forage cover until a burning program can be started.

Disced or brush raked areas can provide needed firebreaks for the prescribed burning program, especially when placed on ridgetops, and in this case slow regeneration is desirable. Although animal use may be limited in this area, it will eventually provide an important control line for prescribed fires.

Lastly, the benefits from hand clearing give us another approach to both direct habitat improvement and the preparation of future firebreaks. The deer response is clearly favorable, and fuel is reduced in a safe (though costly) manner. Areas cleared in this manner can be expected to revegetate as quickly as a burned site.

At this stage in the project, our results indicate the following management combination is the most effective: 1) brush cutting to create firebreaks on ridgetops in areas where burning can be used immediately and 2) brush raking/discing in areas which require several years in order to carry fire. In selecting areas to be burned, all other limiting factors should be considered.

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Growth and Survival of Black Oak Seedlings Under Different Germination, Watering, and Planting Regimes

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Fall-planted black oak seedlings grew and survived better than spring plantations. Summer watering at 2 liters per seedling per week had no effect. Stratified acorns may have a higher survival rate than nonstratified ones and are more synchronized in their germination, making potting more efficient.

The importance of the California black oak (*Quercus kelloggii* Newb.), both as a component of wildlife habitat (*1*) and as a commercial species (*2*), is now widely recognized, but there has been insufficient practical information to develop a formal silvicultural program. Differing views on germination techniques (*3*) and a total absence of direction on planting regimes led us to conduct a study to prepare basic guidelines for oak silviculture on the San Bernardino National Forest. Our interest centered on finding the most effective germination strategy, determining the importance of summer watering of spring-planted seedlings, and comparing spring and fall planting relative to growth and survival.

Study Area

The two experimental plantations were located on southwestern slopes at a 1,400-meter elevation approximately 8 kilometers northwest of Idyllwild, Calif. In general, natural reproduction on prime black oak sites in our area is adequate. Since extension of hardwoods into more marginal (but once forested) habitats was one of our long-range goals, test sites were chosen in chaparral, with predominantly chamise-ceanothus vegetation and coarse granitic soils. Southern California has a characteristic Mediterranean climate with hot, dry summers and cool, wet winters. Rainfall averages 56 centimeters per year.

Materials and Methods

To minimize the effects of genetic variation, all acorns used in the data ($N = 192$) were collected from a single parent tree on September 14, 1979. We picked only acorns that had matured without falling and were visibly free of insect damage.

Acorns were air-cured for 10 days outside in shade, examined again, and sorted for signs of insect attack. Three different germination techniques were tested. The first and second groups were placed in plastic garbage bags along with an equal volume of commercial potting soil and approximately 10 grams of a broad spectrum fungicide (Physan 20). The tips of the acorns (about 3 mm) in the second group were removed, and both groups were kept at room temperature (18° to 24° C) for 90 to 120 days until potting. The third group was similar to the first, but acorns were stratified at 6° C for 45 days and then stored at 18° to 24° C for 45 to 75 days until potting. Each germination group included 21 acorns.

During January 1980, the sprouted acorns were transplanted into 8- by 46-centimeter, open-ended tar-paper pots made from asphalt-saturated roofing felt. The pots had been filled with soil gathered from beneath the parent tree. The filled pots were placed on hardware cloth mesh racks under a 12-hour artificial light regime at room temperature for approximately 100 days until planted or moved outside.

We planted 90 randomly selected seedlings, 30 from each germination treatment, on our two experimental sites between April 28 and May 5, 1980. On the average, seedlings were 7.4 centimeters tall at planting and were not dormant. The spring-planted trees were divided into three watering regimes. The first treatment used a circular berm around the seedling for surface watering. The second, which was developed to minimize evaporation, used a 5- by 60-centimeter black plastic pipe buried with the seedling with the end 5 centimeters above ground and extending at a 45° angle to just below the end of the tar-paper pot. The third group was an unwatered control. Each watering treatment group included 30 individuals.

Spring-planted trees were watered once each week until September with approximately 2 liters per tree per week poured onto the berm or into the watering tube. The amount and interval of watering was deter-

mined by our estimate of what we could integrate into a permanent silvicultural program. We assume that intensive watering will produce bigger trees, but only weekly watering with relatively small amounts is practicable in the field, given existing staffing.

The remainder of the seedlings (102 individuals) were kept in partial shade through the summer and watered liberally at least once per week. They were planted on the experimental sites on September 26, 1980. On the average, they were 7.0 centimeters tall at planting. No leaves had dropped, but slight browning on the edges indicated that dormancy had just begun. Fall-planted trees were not watered.

All trees were protected by 8- by 91-centimeter, plastic mesh (Vexar) tubes covering the entire tar-paper pot and extending 48 centimeters above ground to minimize deer and rodent damage. Spacing between trees averaged 10 meters square on both sites.

Height growth was measured, to the nearest 2/10 centimeter, from the ground's firm surface to the tip of the terminal bud. Readings were taken at planting, at 6 months after planting, and (for spring-planted trees) at 1 year.

Results and Discussion

Germination techniques had no apparent effect on the total percentage of acorns germinated at 7 months after collection and no significant effect (ANOVA test) on mean height at 12 months after planting (table 1). Careful selection of acorns and germination in airtight plastic bags gave a germination percentage in excess of 90 percent in all three treatments. Stratification, recommended by earlier sources (*4*), appears to be unnecessary for black oak germination. However, seedlings from stratified acorns had somewhat higher survival rates; and stratification concentrated germination into a shorter period of time, which made the potting operation more efficient.

Watering made no significant difference (ANOVA test) in growth (table 2). This "negative finding" may be of some importance to hardwood silviculturalists. It may be that

Table 1.—*Effect of germination technique on California black oak seed germination percentage, seedling mean height, and seedling survival*[1]

Seed treatment	Seed germination (after collection)		Seedling mean height (12 mo. after planting)[2]	Seedling survival (12 mo. after planting)
	2 mo.	7 mo.		
	---*Percent*---		*Cm*	*Percent*
Nonstratified, tips removed	30	90+	6.8[3]	80
Nonstratified, tips intact	0	90+	7.5	71
Stratified, tips intact	0	90+	6.9	95

[1]Data include spring-planted trees only.
[2]Mean heights included dead trees as 0, and totals are sometimes lower than mean height at planting.
[3]No significant difference in means (P>.1), ANOVA test.

Table 2.—*Effect of watering on California black oak seedling mean height and seedling survival*[1]

Treatment	Seedling mean height (12 mo. after planting)	Seedling survival (12 mo. after planting)
	Cm	*Percent*
No watering	6.46[2]	77
Surface watering	7.00	86
Tube watering	6.30	82

[1]Data include spring-planted trees only.
[2]No significant difference in means (P>.1), ANOVA test.

watering was not sufficient to achieve an effect. More extensive watering, however, would be too expensive to maintain, whether or not it was successful. In any case, an overall average survival rate of 75 percent suggests that we can grow oaks in chaparral.

Table 3 gives data for height, growth, and survival relative to spring and fall plantings. Fall-planted trees fared significantly better. Fall-planted trees also attained a final average height 12 percent greater. Unpublished data from oak plantations on the Angeles National Forest show a very similar trend.

Since spring and fall trees were the same height at planting, the differences in growth in the field are probably not attributable simply to the added vigor of older trees. It may be that planting just before dormancy allows the trees to adjust more easily to field conditions.

Pending generation of further data, our efforts with black oaks will involve fall collection of acorns, stratification to insure time efficiency in early spring potting, oversummering under shadehouse conditions, and fall planting without watering.

Table 3.—*Mean winter growth, height, and survival of spring- and fall-planted California black oak seedlings*

Planting season	Seedling mean growth Nov. 1980 to Apr. 1981			Seedling survival to Apr. 1981	Seedling mean height to Apr. 1981		
	Site 1	Site 2	Both	Both	Site 1	Site 2	Both
	Cm	*Cm*	*Cm*	*Percent*	*Cm*	*Cm*	*Cm*
Spring	0.68[1]	0.67	0.68[1]	77[2]	8.70	5.20[1]	6.90
Fall	1.50	0.93	1.20	94	7.80	7.60	7.70

[1]Difference between spring and fall means significant (P<.01), *t*-test.
[2]Difference between spring and fall survival significant (P<.01), chi-square test.

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THE EFFECTS OF HABITAT MANAGEMENT ON SMALL VERTEBRATES IN CHAPARRAL

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ABSTRACT

I report the effects of chaparral fuel management by disking, prescribed fire, and hand cutting on rodents, birds, and herpetiles. The rodent community was most sensitive to habitat modification, with the herpetofauna being somewhat less so. The avifauna was least sensitive to habitat modification. Disking was most disruptive to the animal community, with prescribed fire and hand cutting being less so. The effects of chaparral fuel management on the fauna are temporary and are closely related to concomitant changes in the plant community.

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INTRODUCTION

The chaparral of California is frequently managed to lessen the problems of wildfire by reducing the quantity of vegetation available to burn. Fuel reduction can be accomplished by type conversion, which usually replaces shrubs with herbaceous vegetation. It can also be done with prescribed fire, which eliminates the large quantities of fuel in mature shrubs by burning. Fire by prescription is sometimes used systematically over entire watersheds, as has been the case on the Grindstone Project in Northern California. By contrast in the steep, partially urbanized chaparral of the Southern California mountains prescribed fire must usually be applied on a smaller scale. In recent years the advent of the helitorch has made the burning of chaparral by prescription a more attractive management alternative for both large and small fires. The effects of these relatively new management activities on wildlife, particularly with the expanded use of the helitorch by the United States Forest Service, California Division of Forestry, Bureau of Land Management and others, has not yet been fully assessed.

In 1974 the large and potentially catastrophic Soboba Wildfire occurred in the San Jacinto Mountains. The Soboba Project was undertaken after this fire. This project is a 12,000 acre demonstration area in the San Bernardino National Forest where various approaches to improving wildlife habitat have been combined with a fuel reduction and management program. The project

is somewhat unusual in that the creation and improvement of wildlife habitat is one of its primary goals, and because attention has been given to non-game as well as game species.

This paper reports on these wildlife studies, which were carried out between 1979 and 1982. Our studies concentrated on rodents, birds, and herpetiles. We studied these three groups of vertebrates in experimental areas where chaparral fuel was reduced by disking, prescribed fire, and hand cutting.

This paper also describes a method of efficiently measuring the condition of several groups of organisms along a single wildlife assessment line.

METHODS

Study Site

Three experimental areas within the demonstration area were selected for monitoring. Two of these were in six year old chaparral inside the boundaries of the Soboba Wildfire, and the third was in old chaparral that had not burned for 30 or more years. All three areas are located within the San Bernardino National Forest, Riverside County, California. The areas were within three miles of one another, less than two miles south and west of the Vista Grande Ranger Station, at elevations of 4200-4400 feet.

Wildlife Assessment Lines

Wildlife assessment lines were used to monitor the rodent, bird, and herpetile communities at all three experimental areas. Lines were situated on ridge tops and hillsides, with the lines bending in conformity with the topography. Lines were arranged with 12-15 sampling stations within each manipulation, and an equal number of control stations on extensions of the line outside the manipulated areas (Figure 1). Each station contained a Sherman live trap for rodents, and a five gallon metal can buried in the ground as a pitfall trap for small herpetiles. These stations were also used as observation points for birds, and as reference points for plant sampling.

A Sherman live trap was placed within one meter of each sampling stake. Each rodent captured was identified by species

and sex and permanently marked by toe clipping. Traps were operated for 4-9 nights per season, until approximately 75 percent of all animals captured on the final night of trapping were recaptures.

The trapping season in the Fall of 1979 preceded the manipulations of the vegetation, all of which occurred in the Winter and/or Spring of 1980. The 1980 trapping season took place in the Fall, after manipulation of the vegetation. The hand cut area was not trapped at that time because of the recent disruption of the area caused by the cutting. The 1981 trapping occurred in the Spring.

Bird observations were made at each experimental site in the Fall of 1979 and 1980, and in the Spring of 1981. During each morning of observation all species of birds observed along an assessment line were recorded while walking slowly and stopping at every other sampling station for five minutes. All observations were made in the early morning hours. Each line was observed 2-4 mornings in each season.

The pitfall traps for herpetiles were buried such that the circular openings in the top of each can were flush with the surface of the ground. Cans were placed 2-3 meters from each station, perpendicular to the assessment line, on alternating sides (Figure 1). The top of each can was covered with a plywood square which was raised on pegs to rest 1-2 cm above the ground. This left a crawl space beneath the lid, so that herpetiles that ran beneath would fall into the can. This device succeeded in catching all four species of lizards common in the area. Traps

were inspected every two weeks. Each lizard captured was identified to species and released. Traps were left open for 39-78 days in the Fall of 1979, 14-36 days in 1980, and 37 days in the Spring of 1981. In addition to the captures, other herpetiles were recorded when observed on or near the assessment lines.

Manipulation of the Vegetation

1. Disking. In February of 1980 six year old chaparral was removed from a 35 meter wide strip on a ridgetop, using a Towner disk pulled by a Caterpillar D-7 crawler tractor. A Towner disk is a much larger, heavier model of the common farm implement. This machine uproots, chops, and buries the chaparral shrubs.

2. Prescribed fire. In June of 1980 mature chaparral was ignited from the air with a helitorch, under weather conditions where the fire was safely contained. The experimental fire was patchy, removing 75 percent of the vegetative cover along the assessment line and 40-50 percent of the cover from the general fire area.

3. Hand cutting. In the Winter and Spring of 1980 a 35 meter wide strip of six year old chaparral was removed from a ridgetop by chopping the shrubs down at ground level with hand tools, and stacking the cuttings in piles. The piles of cuttings were left in place to dry for several months, and then burned. This procedure, since it did not disturb the soil, allowed new ground cover to become established relatively quickly from seedlings and from resprouts of the stumps of the cut shrubs.

Vegetation Analysis

Vegetation was sampled in the experimental and control portions of all three areas by means, with one exception, of line intercept sampling. Samples were taken in 1980-81, after manipulations were completed. Sampling was done along the wildlife assessment lines using 15-30 segments, each 5 meters in length, in both the manipulated and unmanipulated vegetation. The experimental area manipulated by disking was sampled using 15 circular sample plots, one meter in diameter, placed at five meter intervals. From these data percent relative plant cover was calculated, counting bare ground as if it were a plant (Table 1). Percent relative cover concisely conveys the importance of each plant species in the structure of the habitat, and shows the large differences between manipulated and control areas.

RESULTS AND DISCUSSION

Rodents

Five species of rodents were captured, in varying numbers, at the three experimental sites. Trapping results were analyzed to compare relative habitat use (Table 2) between treated and untreated areas. Relative habitat use was estimated from the total number of captures per season. Differences in habitat use between the experimental and control areas were tested for statistical significance by the Chi-square test, comparing the total number of captures with the total number of trap nights.

1. Disking. Prior to disking there was no significant difference between the experimental and control stations along the wildlife assessment line (Table 2). Both were dominated by _Dipodomys agilis_ (Pacific kangaroo rat), with somewhat fewer numbers of _Peromyscus_ (White-footed mice). This is a pattern that is typical of young chaparral (Quinn, 1979). _D. agilis_ uses the openings between the shrubs, which accounted for approximately 1/4 of the total ground area in this young chaparral (Table 1). _P. californicus_ (California mouse) and _P. boylii_ (Brush mouse), on the other hand, forage in the shrubs (Quinn, 1979, 1983). Habitat use increased in the control area in 1980 and 1981, and _D. agilis_ and _P. californicus_ continued to be the most common species. After disking, which destroyed nearly all vegetative cover (Table 2), most small mammals disappeared from the treated area. There was a 79 percent reduction in habitat use. The two species that

require vegetative cover, P. californicus and P. boylii, disappeared altogether from the treated area in 1980. The difference in habitat use in 1980 between the experimental and control areas was statistically significant. By 1981 all species present before disking had returned to the experimental area, but habitat use was still significantly reduced in comparison to the control. Peromyscus maniculatus (Deer mouse), which became more common in the experimental area by 1981, is characteristic of disturbed areas in chaparral. This species forages on the ground in weedy, disturbed areas (Quinn, 1979), and has been reported by Carnes (1978) to become abundant after removal of mature chaparral by heavy equipment. D. agilis survives chaparral habitat disturbances in the deepest parts of its burrow system (Quinn, 1979), and flourishes afterwards in the environment that has been created. These burrows can be 40 or more cm deep (Quinn, unpublished data). Three of the seven individual D. agilis found in the disked area in 1980 were survivors of the manipulation, and the populations of both this species and P. maniculatus more than doubled between 1980 and 1981. I would predict that the number of captures in the experimental area would have exceeded that of the control by 1983.

2. Prescribed fire. Relative habitat use declined in the experimental area between 1979 and 1980, even though habitat use increased in the control (Table 2). By 1981 relative habitat use was significantly lower in the fire area. In the year following the fire

Neotoma fuscipes (Dusky-footed wood rat) was absent from the experimental area. This happened because its flammable stick nests were destroyed by the fire, and because it requires the dense and continuous cover of mature chaparral (Quinn, 1979; Horton and Wright, 1944). By 1981 *D. agilis*, which flourishes in the first 2-4 years after chaparral wildfires (Wirtz 1977, 1983; Quinn 1979, 1983; Bayless, 1980), had increased in numbers. *P. californicus*, which uses areas with mixed shrubs and open areas, was the most abundant species in both experimental and control areas.

3. Hand cutting. In 1981, one year following hand cutting, habitat usage was significantly less in the treated area (Table 2). In the experimental area the population of *P. maniculatus* increased relative to both the pre-treatment levels and to the control while *D. agilis* declined. In the control area *N. fuscipes* increased in numbers, and *P. californicus* increased greatly. There is no obvious explanation for the population increase of *P. californicus* in the control area, but it is noteworthy that similar increases also occurred in the controls for the other two experimental areas.

Birds

A total of 59 species of birds were observed on the three wildlife assessment lines in the three seasons. The total number of species was quite similar for all three areas in one season, and for each area for all three seasons combined (Table 3). Since

individual birds can move freely in and out of the relatively small treated areas, these were observations of habitat selection in the behavior of individual birds.

The 13 most frequently observed species of birds are listed in Table 4. All are common species of chaparral birds that are conspicuous due to their calls, flocking, flying, or some other aspect of their behavior. By contrast 11 species of birds were sighted only once. The mean number of observations for all 59 species combined was 3.42.

Neither prescribed fire nor hand cutting significantly reduced the number of species using those two manipulated habitats. Disking did cause a significant reduction in the number of bird species using the treated area in 1980, but by 1981 there were equal numbers of species using the treated and untreated areas (Table 3). This temporary reduction in the number of bird species is probably due to the extent of the impact of disking on the plant community, which was greater than that of the other manipulations. Both hand cutting and fire allowed for the rapid reestablishment of some shrub cover by resprouting during the following Spring and Summer (Table 1). Disking, on the other hand, destroyed the root systems of the shrubs, and thus prevented their rapid regrowth by resprouting. Only sparse vegetation grew in the disked area before the Spring of 1981, when grasses became established.

The limited effect of prescribed fire on the avifauna

may have been partly due to the patchiness of the fire. Burned areas were small, so that unburned chaparral shrubs were always nearby. After a prescribed fire in chaparral that only partially removed the existing plant cover, Dutton (1981) found no significant change in the structure of the avifauna that was attributable to the fire. A prescribed chaparral fire in the foothills of the Sierra Nevada Mountains was followed by an increase in the number of bird species (Lawrence, 1966). Even after a large chaparral wildfire that removed all vegetative cover, Wirtz (1977, 1979, 1983) reported that numerous species of birds were present and that avian repopulation of the fire area was rapid.

Herpetiles

Four common species of chaparral lizards were captured in the pitfall traps: side-blotched lizard (*Uta stansburiana*), western fence lizard (*Sceloporus occidentalis*), western whiptail (*Cnemidophorus tigris*), and coast horned lizard (*Phrynosoma coronatum*). Two other species of lizards, the California legless lizard (*Anniella pulchra*) and granite night lizard (*Xantusia henshawi*) were observed. The latter species is at the northern limit of its distribution in the San Jacinto Mountains.

Four species of snakes, all common in chaparral, were observed but not captured: southern pacific rattlesnake (*Crotalus viridus helleri*), red diamond rattlesnake (*Crotalus ruber*), striped racer (*Masticophis lateralis*), and the gopher snake (*Pituophis

melanoleucus).

In 1980 disking significantly reduced the number of captures of herpetiles in the experimental area, both as compared to the control and as compared to the season prior to manipulation (Table 5). By 1981 the number of captures in both experimental and control areas was the same. The small number of captures in the experimental area in 1980 was probably due to the lack of vegetative cover, and perhaps the lack of underground refugia after the thorough stirring of the soil during disking.

Before the prescribed fire the experimental area had a significantly higher number of herpetile captures than did the control (Table 5). In 1980, after the fire, the difference was reversed; the experimental area had significantly fewer captures than the control. In 1981 there were very few captures in both the experimental and control areas. The 1980 pattern is consistent with the findings of Lillywhite (1977a, 1977b), who reported that the lack of vegetative cover shortly after a chaparral fire was associated with low population densities of lizards. Similarly, in a study of reptiles in chaparral Simovich (1979) found small numbers of lizards in the first year after a wildfire.

In 1979 the experimental hand cut area had significantly more lizard captures than the control (Table 5). In 1980 there was no significant difference between the number of captures in the experimental and control areas, and in 1981 the number of captures

were almost identical in experimental and control areas. Furthermore, in all three years the same species were caught, and in similar proportions, in both experimental and control areas.

Summary and Conclusions

Of the three groups of small vertebrates, rodents were the most sensitive to the habitat modifications. All three manipulations significantly reduced the number of rodent captures. In the prescribed fire and hand cut areas, however, this decline would be temporary. Rodent populations would rapidly increase in response to the rapid regrowth of the vegetation.

Herpetiles were somewhat less sensitive to habitat modification, showing significant declines in captures only in the first season after manipulation, and only in response to disking and prescribed fire. These declines were somewhat obscured by the variability in capture rates between and within assessment lines. This variability apparently had nothing to do with the manipulations.

Bird behavior was least affected by the three manipulations, with a significant reduction in the number of species sighted only after disking and only in the first season after that manipulation.

Of the three manipulations disking was the most disruptive, significantly reducing all three groups of small vertebrates. Furthermore, despite the apparent recovery of both the bird and herpetile communities by the second season after disking, it is likely that there were longer range effects on these animals

that could be measured with more sensitive sampling methods.

Disking replaces chaparral with forbs and grasses that can persist for many years. The structural simplicity of that plant community makes it less capable of supporting a wide variety of smaller species of animals, although some species such as kangaroo rats, black-chinned sparrows, and side-blotched lizards could become quite abundant. Prescribed fire and hand cutting, on the other hand, produce a mix of herbaceous vegetation, subshrubs, and rapidly growing shrubs. This type of plant community will support a great variety and abundance of wildlife, particularly if it is closely associated with other age classes of chaparral and other plant communities.

As fuel management is systematically applied on an ever growing scale throughout the chaparral of California, there will be an increasing need for research into the effects of this activity on wildlife. This is particularly true of prescribed burning from the air, which is only now becoming widespread. Just as fuel management specialists are becoming more expert at using fire to produce a safer and more productive chaparral environment for the citizens of the State, we who study and manage wildlife must become equally knowledgable about its effects on wildlife. In this way we can cooperatively plan for chaparral management that maximizes benefits to wildlife while accomplishing other goals. Further research is called for.

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TABLE 1. Percent relative plant cover on three wildlife assessment lines.

A. DISKING

Species	EXPERIMENTAL	CONTROL
Bigberry Manzanita (*Arctostaphylos glauca*)		42.2
Chamise (*Adenostoma fasciculatum*)		16.8
Ceanothus (*Ceanothus leucodermis*)		10.4
Mountain Mahogany (*Cercocarpus betuloides*)		8.1
Bare Ground	83.7	23.1
Orchard Grass (*Dactylis glomerata*)	6.7	
Others	9.6	

B. PRESCRIBED FIRE

Species	EXPERIMENTAL	CONTROL
Bigberry Manzanita (*Arctostaphylos glauca*)	14.3	40.3
Chamise (*Adenostoma fasciculatum*)	8.6	36.0
Bare Ground	77.1	23.7

C. HAND CUTTING

Species	EXPERIMENTAL	CONTROL
Bigberry Manzanita (*Arctostaphylos glauca*)	9.6	26.1
Ceanothus (*Ceanothus leucodermis*)		25.1
Chamise (*Adenostoma fasciculatum*)		17.2
Bare Ground	76.5	28.1
Others	13.9	3.5

TABLE 2. Relative habitat use. The number of captures of five species of rodents before and after manipulation of the vegetation. No hand cutting data for 1980.

A. DISKING

	EXPERIMENTAL			CONTROL		
Species	1979	Disking ↓ 1980	1981	1979	1980	1981
Dipodomys agilis	35	7	22	23	24	47
Peromyscus californicus	4		2	16	32	53
Peromyscus boylii	6		6			3
Peromyscus maniculatus	2	3	7		4	1
Neotoma fuscipes				3		
TOTALS:	47	10*	37*	42	60	104

B. PRESCRIBED FIRE

	EXPERIMENTAL			CONTROL		
Species	1979	Fire ↓ 1980	1981	1979	1980	1981
Neotoma fuscipes	9		1	8	6	11
Peromyscus californicus	13	8	21	3	20	36
Dipodomys agilis	5	2	13	1		5
Peromyscus maniculatus		2	5			3
Peromyscus boylii		7	1			3
TOTALS:	27**	19	41**	12	26	58

C. HAND CUTTING

	EXPERIMENTAL			CONTROL		
Species	1979	Hand Cutting ↓ 1980	1981	1979	1980	1981
Peromyscus maniculatus	13	-	31	11	-	13
Dipodomys agilis	16	-	2	11	-	8
Peromyscus californicus	4	-	3	6	-	41
Neotoma fuscipes		-		3	-	9
Peromyscus boylii	1	-			-	
TOTALS:	34		36**	31		71

*Significantly lower than the control by Chi-square test, $p < 0.01$.
**Significantly different than the control, $p < 0.025$

TABLE 3. Number of bird species sighted on three wildlife assessment lines. E = experimental, C = control. No data for handcutting in Fall 1980.

	Fall	Fall 1980			Spring 1981			1979-81
Treatment	1979	E	C	E & C	E	C	E & C	Total
Disking	21	9*	18	20	13	12	21	39
Prescribed Fire	19	11	13	17	11	17	23	35
Hand Cutting	24	-	-	-	15	16	21	35

* Significantly lower than the control by Chi-square test, p 0.01.

TABLE 4. Bird species observed 5 or more time on the wildlife assessment lines.

Species	Number of Observations
Wrentit (*Chamaea fasciata*)	29
Scrub jay (*Aphelocoma coerulescens*)	20
Rufus-sided towhee (*Pipilo erythrophthalmus*)	19
California thrasher (*Toxostoma redivivum*)	13
Bushtit (*Psaltriparus minimus*)	10
Red-tailed hawk (*Buteo jamaicensis*)	9
Lesser goldfinch (*Spinus psaltria*)	8
Black-chinned sparrow (*Spizella atrogularis*)	7
Common raven (*Corvus cryptoleucus*)	7
Bewick's wren (*Thryomanes bewickii*)	7
Dark-eyed junco (*Junco hyemalis*)	5
Common Flicker (*Colaptes auratus*)	5
Brown towhee (*Pipilo fuscus*)	5

TABLE 5. Relative habitat use. The number of captures of six species of herpetiles before and after manipulation of the vegetation.

A. DISKING

Species	EXPERIMENTAL Disking 1979	1980	1981	CONTROL 1979	1980	1981
Uta stansburiana	30		10	17	1	3
Sceloporus occidentalis					2	3
Sceloporus graciosus		5	4		12	2
Sceloporus sp.	10			8		
Cnemidophorus tigris						6
TOTALS:	40	5*	14	25	15	14

B. PRESCRIBED FIRE

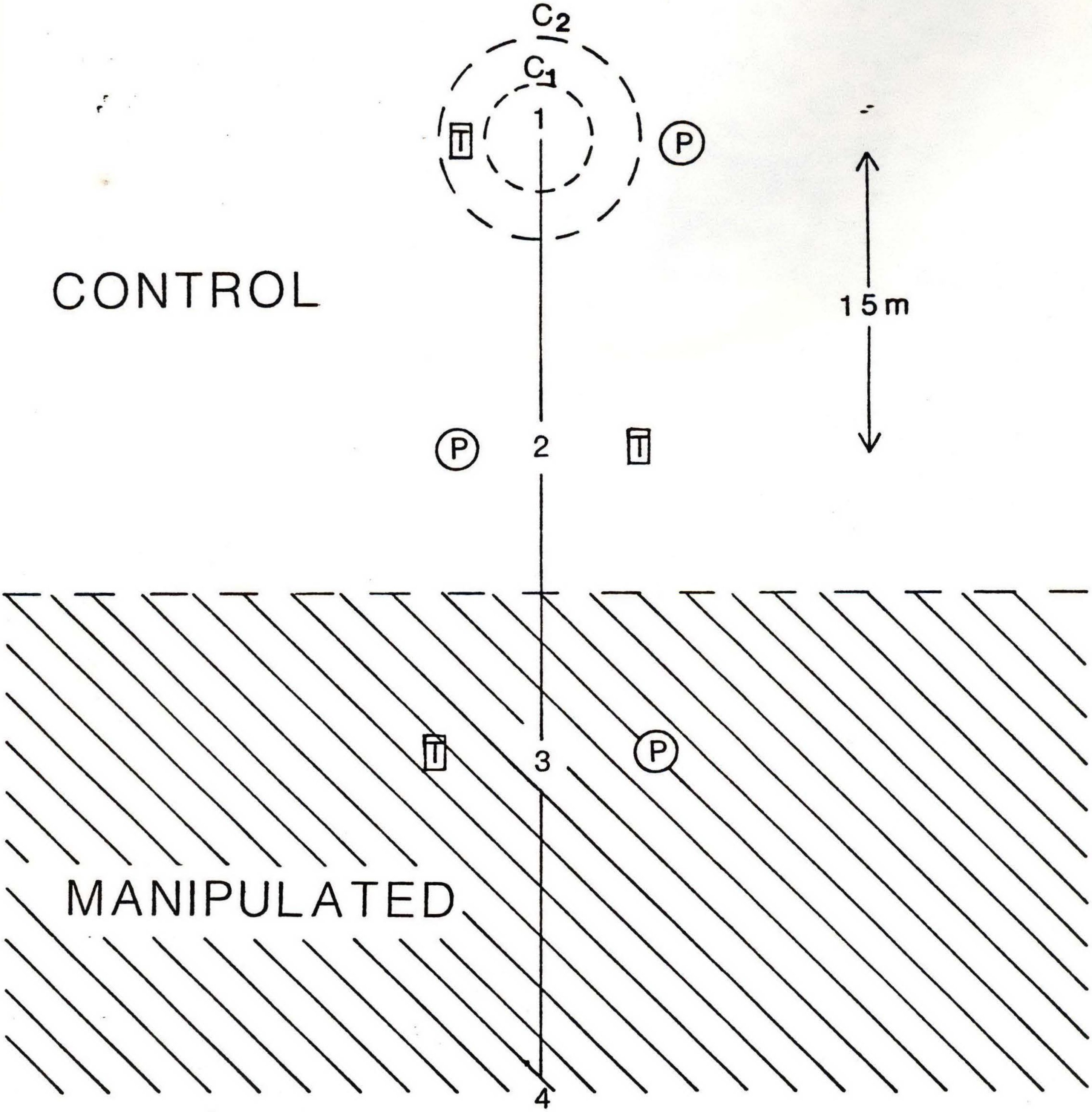
Species	EXPERIMENTAL Fire 1979	1980	1981	CONTROL 1979	1980	1981
Uta stansburiana	17	6		2	10	1
Sceloporus occidentalis						3
Sceloporus sp.	4	2		1	16	
Cnemidophorus tigris			4		1	2
Phrynosoma coronatum					1	
Bufo boreas					1	
TOTALS:	21***	8***	4	3	29	6

C. HAND CUTTING

Species	EXPERIMENTAL Hand Cutting 1979	1980	1981	CONTROL 1979	1980	1981
Uta stansburiana	36	13	10	20	6	5
Sceloporus occidentalis			6			10
Sceloporus graciosus			5			4
Sceloporus sp.	23	12		15	9	
Cnemidophorus tigris			12			12
TOTALS:	59**	25	33	35	15	31

*Significantly lower than the control, by Chi-square test, $p < 0.05$.
**Significantly different than the control, $p < 0.02$.
***Significantly different than the control, $p < 0.001$.

Figure 1. Three sampling stations on a wildlife assessment line. Sampling stations are 15 meters apart, with a pitfall trap (P) and a rodent live trap (T) at each station. Sampling stations can also be used as reference points for linear plant sampling, observation of birds by transect, and as the centers of circular pellet plots for small (C_1) and large (C_2) mammals.



C2
C1
1
T
P
CONTROL
15 m
P
2
T
T
3
P
MANIPULATED
4